Charmonium Suppression by Comover Scattering in Pb+Pb Collisions *

S. Gavin† *and R. Vogt*

Experiment NA50 has reported an abrupt decrease in ψ production in Pb+Pb collisions at 158 GeV per nucleon [1]. Specifically, the collaboration presented a striking 'threshold effect' in the ψ-to-continuum ratio by plotting it as a function of a calculated quantity, the mean path length of the ψ through the nuclear medium, L. This apparent threshold has sparked considerable excitement as it may signal the formation of quark-gluon plasma in the heavy system.

We study the Pb results in the context of a hadronic model of charmonium suppression [2]. We point out that the behavior as a function of L is not a threshold effect but, rather, reflects the approach to the geometrical limit of L as the collisions become increasingly central. When plotted as a function of the measured neutral transverse energy E_T, the data varies smoothly as in S+U measurements [1]. The difference between S+U and Pb+Pb data lies strictly in the relative magnitude. To assess this magnitude, we compare ψ and ψ' data to expectations based on the hadronic comover model [2].

The hadronic contribution to the suppression arises from scattering of the ψ with produced particles, comovers, and nucleons [2]. The standard nucleon absorption survival probability is

$$S_A = \exp\{-\int_z^\infty dz\, \rho_A(b,z)\sigma_{\psi N}\} \qquad (1)$$

where ρ_A is the nuclear density, b the impact parameter and $\sigma_{\psi N}$ the absorption cross section for ψ–nucleon interactions. One can estimate $S_A \sim \exp\{-\sigma_{\psi N}\rho_0 L_A\}$, where L_A is the path length traversed by the $c\bar{c}$ pair.

Suppression can also be caused by scattering with produced particles traveling with the $c\bar{c}$ pair. This comover density scales $\propto E_T$. The corresponding survival probability is

$$S_{\rm co} = \exp\left\{-\sigma_{\rm co} v n_0 \tau_0 \ln\left(\frac{\tau_F}{\tau_0}\right)\right\}. \qquad (2)$$

Thus $S_{\rm co}$ depends on the scattering frequency, the formation time of the comovers and the transverse size of the central region. The comover density, n_0, scales roughly with E_T.

The path length L and transverse size R_T depend on the collision geometry. The path length grows with E_T, asymptotically approaching the geometric limit $R_A + R_B$. Nucleon absorption saturates for $b < R_A$, where R_A is the smaller of the two nuclei. On the other hand, E_T continues to grow for $b < R_A$ due, *e.g.*, to fluctuations in the number of NN collisions.

Our Pb+Pb predictions account for the NA50 data. Nucleon absorption indeed saturates for small values of b. Comover scattering accounts for the remaining suppression. To compare our predictions with the NA50 analysis [1], we calculate the continuum dimuon yield for $2.9 < M < 4.5$ GeV and adjust the E_T scale to the NA50 calorimeter, $1.1 < \eta < 2.3$. The agreement depends on these updates. The saturation with L but not E_T suggests an additional density-dependent suppression mechanism. Comover scattering explains the additional suppression. Nevertheless, it is unlikely that this explanation is unique.

[1] M. Gonin *et al.* (NA50), Proc. Quark Matter '96, Heidelberg, Germany, P. Braun-Munzinger *et al.*, eds. (1996).

[2] S. Gavin and R. Vogt, Nucl. Phys. **B345** (1990) 104; S. Gavin, H. Satz, R. L. Thews, and R. Vogt, Z. Phys. **C61** (1994) 351; S. Gavin, Nucl. Phys. **A566** (1994) 383c.

*LBL-37980; to be published in Phys. Rev. Lett.

†Physics Department, Brookhaven National Laboratory